A High Intensity Neutrino Beam Using 8 GeV Protons

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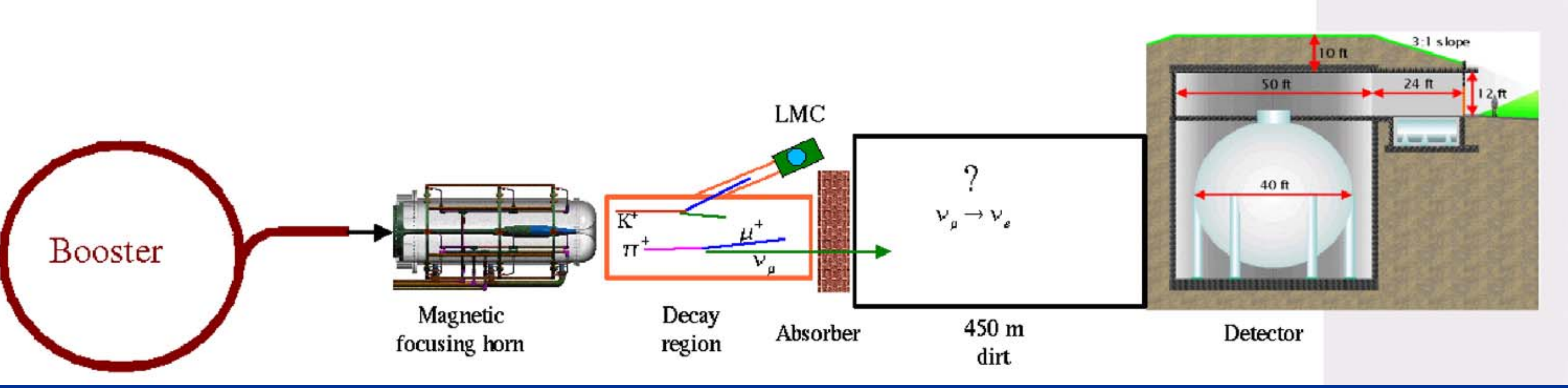
Outline

- Overview of MiniBooNE technology
- Attempt to extrapolate some of the existing MiniBooNE technology and physics to a high intensity source
- Will not discuss the new technology which must be developed… (the hard work)
- Physics Goals and possibilities

MiniBooNE System



8 GeV Proton Beam Line

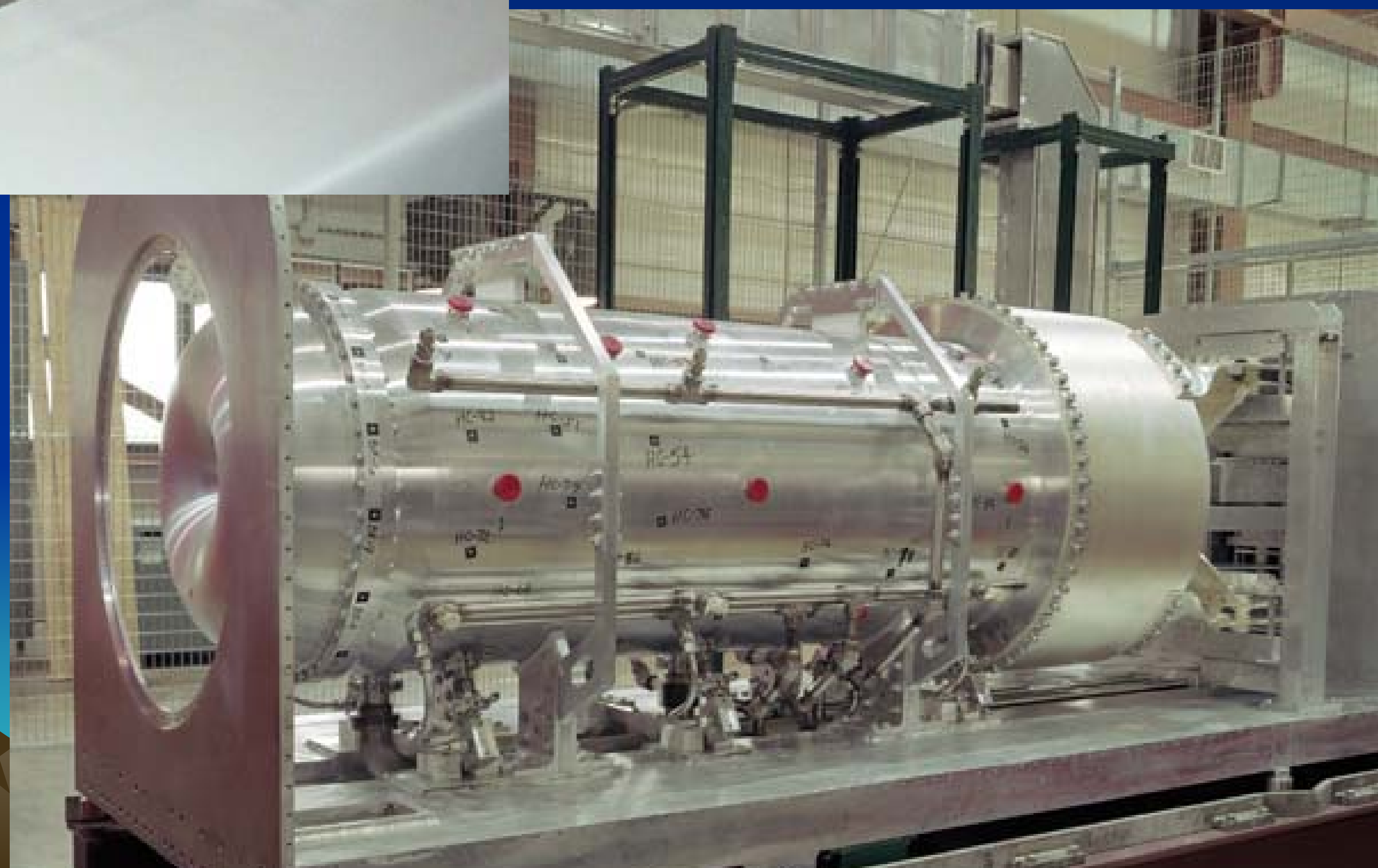
Target Hall

Target Pile

Decay Tunnel

Beryllium Target and Magnetic Horn

2.5 KV
170 KA
143 μs
5 Hz



Magnetic Horn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High Intensity Horn/Target?

- Air activation a serious problem (sealed system?)
- Heat load on target increases from 600W to 9kW or 36kW , current system will not work!
- Magnetic horn is probably still useable(?)
- Shielding is not sufficient in beam line, target hall, and or

Motivation

- Interesting hints in high Δm^2 from LSND
  - MiniBooNE will likely probe in neutrinos, but definitive anti-neutrino run still not certain
- Possible high m from neutrino-less double beta decay experiments (~0.4 eV)
- Possible atmospheric θ_{13} (?) measurement

Neutrino Mass

- Questions
  - Are there light sterile neutrinos?
  - Is there CPT in the neutrino sector
- To answer these, we need:
  - a full program of neutrino and anti-neutrino running
  - Two detector system to eliminate systematic errors from flux and cross section

8GeV Proton Driver Options

- Current Linac/Booster
  - 0.032 kW, 5E20 p/yr
- Phase 1 MW SCRF Linac
  - 0.5 MW, 7.5E21 p/yr
- 2.0 MW SCRF Linac
  - 2.0 MW, 3.1E22 p/yr

Physics Goals

- Continuation of MiniBooNE program to full BooNE program (2 detectors)
  - Anti-neutrinos
  - Neutrino disappearance
  - Sensitivity to sterile neutrinos (NC/CC)
  - Easily done with 0.5MW Proton Driver
- Extension to atmospheric Δm^2 in ν_e appearance

Method

- Goal is to use quasi-elastic neutrino processes
  - well understood cross section (or will be..)
  - Good correlation between outgoing lepton momentum and neutrino energy (event by event E_ν)
  - These reactions dominate in the 200MeV-1000MeV neutrino energy range
- Backgrounds from K and π^0 are lower at lower beam energies (8 GeV is even a little high)
- Lower energy neutrino interactions are contained more easily in small detectors

Experience

- MiniBooNE and LSND have provided much experience with regard to event reconstruction performance and selection efficiencies
- Event rates from 8 GeV beam line well known at this point
- Experience with horn/target will be useful also

Anti-neutrino near event rates

- 0.5 MW Option
  - 400k anti-neutrino interactions/yr (in MiniBooNE like detector)
  - Comparable to current MiniBooNE neutrino rates
- 2.0 MW Option
  - 1.6E6 events/yr
  - Could repeat MiniBooNE in a few months!

Sensitivity to Atmospheric Oscillations

- Extrapolate from Δm^2=0.4eV^2 , L = 500m to Δm^2=2.5E-3eV^2, L=80km
- Increase detector mass from 0.45kT to 5kT
- $1/r^2$ reduces rate by 2.56E-4
- Result:
  - 0.5MW source: 204*P_{osc} signal events with 5.5 background (3% P_{osc} sensitivity)
  - 2.0 MW source 812*P_{osc} signal events with background of 22 (1.7% P_{osc} sensitivity)

Conlcusions

- A high intensity 8GeV source could provide a very interesting physics program
  - Complete the BooNE physics program
    - Antineutrino running
    - Two detector implementation
  - Have sensitivity to atmospheric oscillations with a far detector (~30M$)